International Energy Agency Technology Collaboration Programme on
District Heating and Cooling including Combined Heat and Power

Annex XII final report summary for a non-technical audience

Effects of Loads on Asset Management of the 4th Generation District Heating Networks

Project short title:

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Summary Report

IEA DHC Annex XII project "Effects of loads on asset management of the 4th generation district heating networks" investigates the influence of future mechanical and thermal load spectra on the service life of pre-insulated bonded single pipes. The latter represent the majority of currently operating DH pipelines, based on the 3rd generation technology (3GDH). 4th generation DH networks (4GDH) operate at lower temperatures, also integrating renewable energy sources, that are more volatile compared to operating loading in traditional DH. The lower levels of operating temperature, and the increased amount of cyclic loading influence ageing and the service life of 4GDH networks, requiring proper analysis of the system performance.

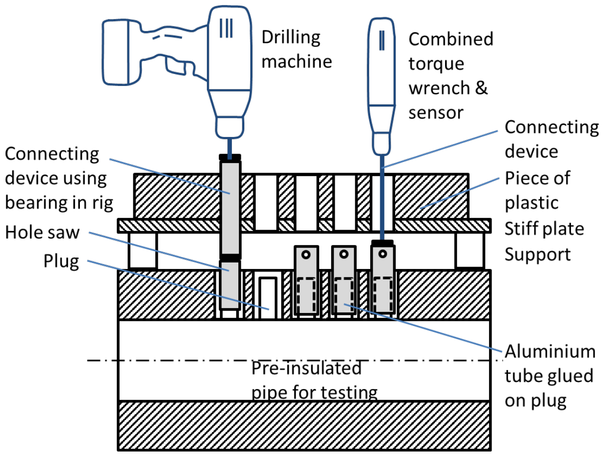
To evaluate the material durability of operating 4GDH pipelines, this research project analyses the behaviour of the service steel pipe, the insulation foam, and their adhesive interaction, using an innovative analytical and experimental procedure.

First, the thermal fatigue life of DH pipes, is evaluated considering temperature history data collected from operating DH pipelines in Germany, Sweden, Norway, and South Korea. The analysis results indicate that, the lifetime of 4GDH pipelines is expected to increase, compared to conventional DH, because of the lower operating temperature, and the lower impact of thermal loading volatility in the network. In the analyzed solar DH network, the thermal fluctuation is limited within the solar thermal field, associated with the typical day-night solar thermal cycles, while decreasing abruptly in the rest of the system, due to the controlling measures of the DH company. Other 4GDH systems with more plannable heat sources, like waste, biomass, geothermal, are expected to have even a lower temperature fluctuation, due to the absence of any localized volatility, as in the solar thermal field, and the controlling strategy of the DH operator.

The analysis of the shear strength data from naturally aged pipes showed that thermal loading and pipe material significantly influence the pipe shear strength, requiring detailed information on the DH system during the operational lifetime.

The performed accelerated ageing tests (Figure 1) demonstrated that the combined effect of mechanical loading and thermal ageing accelerates the rate of chemical

degradation of the PUR foam, leading to a faster deterioration of the adhesion strength. Clearly, the most severe conditions are at the interface between the steel pipe and the foam material, undergoing larger strains and more chemical changes, triggered by the higher thermal and mechanical load. The Fourier-transform infrared spectroscopy (FTIR) analyses, conducted on PUR plugs from the mechanical tests, demonstrated the higher deterioration rate of the PUR material, induced by thermal and mechanical ageing.



a) b)

Figure 1. a) view of the electrical and mechanical test installation; b) schematic representation of the mechanical testing.

The experimental analysis of the naturally aged DH pipelines (Figure 2) showed that, in addition to the ageing time, the shear strength of DH pipes depends on the temperature history, decreasing with the level of operating temperature and amount of fluctuation. The results of FTIR analysis performed on naturally aged DH pipe samples showed similar material deterioration mechanisms, as in the case of artificial ageing at 130~140°C with cyclic loads. This proves that the new accelerated ageing techniques proposed in this study represent well the natural ageing conditions.

a) b)

Figure 2: a) View of the test specimen before the test, and b) shear strength test set-up.

Finally, it is recommended to document the operating temperature history and the most important properties of the pipe system before installation, as well as during operation, contributing to better predictive maintenance, and subsequent reduction of economic risks for replacement and repair. Moreover, to accurately estimate the fatigue damage, the measuring time interval in the temperature data should be sufficiently small, highlighting the importance of the data logging process.

In conclusion, the obtained results give a better understanding of the performance of traditional and 4GDH pipelines in operation, that need to be considered in the engineering design standards of DH networks, contributing to a more sustainable and energy efficient infrastructure.